Innovative Historical Ecology Trend Analysis and Interpretation for the Monterey Bay National Marine Sanctuary

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Executive Summary

Historical information is vital for resource managers and scientists trying to understand how the past has affected the present, and how our actions today may affect the future. However, historical data is not always readily available or organized in such a way that is useful for those trying to benefit from it; therefore, we initiated the Monterey Bay National Marine Sanctuary Historical Ecology Project (Project). There is a wealth of useful historical ecological data pertaining to the Monterey Bay National Marine Sanctuary (Sanctuary or MBNMS), with topics ranging from coastal water quality to demersal fisheries. Given that the theme of the 2009 Sanctuary Currents Symposium (http://montereybay.noaa.gov/research/currsymp2009/welcome.html) was the natural history of the Sanctuary, and recent efforts by Sea Grant Fellows working at the MBNMS resulted in a large database of historical documents, this is an opportune time to more closely examine these data and create a product that can be useful for resource managers, scientists and other interested persons alike.

The Project consisted of two phases. In Phase 1, Selbie (2008) searched Internet and library archives for documents pertaining to the natural history of the Sanctuary. The search resulted in over 300 records that were then entered into the Marine Historical Database (Database), which can be queried with a variety of search tools. Phase 2 of the Project, detailed in this report, provides an example of how historical documents from the Database can be used to analyze ecological trends following methods outlined in

Palomares et al. (2005) and Pandolfi et al. (2003). More specifically, anecdotes from which biodiversity and the relative abundance of certain species found in the Sanctuary could be inferred were collected an analyzed. Additionally, the information collected for the analysis portion of Phase 2 was entered into an internet-based interactive timeline (www.sanctuarysimon.org/timeline).

The analysis portion of Phase 2 of the Project revealed a general decrease in the perceived abundance of selected marine fauna when compared to the historical record. While data points were limited once the information was filtered, the timing of these declines in perceived abundance appear to match well-documented trends in the Sanctuary's ecological past. The timeline is populated with over 100 clickable buttons which display anecdotes, historical facts, background information that links the people of Monterey Bay with their environment, and in most cases, a photograph.

While the types of analyses performed were not novel, the interpretation of the data using those methods is unique for the Sanctuary. Furthermore, the data analysis portion provided a more tangible link between anthropogenic history, attitudes, perceptions, and the marine environment. The marine historical timeline displays this complex relationship in a way that can be easily accessed and viewed. Everyone, from those interested in learning more about the Sanctuary to scientists and resource managers planning for the future of the MBNMS, can use these data and the timeline to better understand the complexities of human impacts on marine ecosystems and the impacts that marine ecosystems have on humans.

Introduction

As resource managers and scientists try to anticipate and prepare for future challenges in marine conservation, such as climate change, ocean acidification, depletion of fish stocks, harmful algal blooms, or invasive species, one thing that cannot be marginalized is the past. Historical data in its various forms can provide valuable information, from simple corroborating information used in everyday outreach and education efforts, to complex reference points and benchmarks used in restoration and mitigation projects. If ignored, decision makers and researchers could be lacking critical information vital to the successful management and protection of natural resources. The use of information such as archaeological finds, historical records, and even old journals to aid in the management of ecosystems is not new. Applied historical ecology, as it is known, has been extensively used in terrestrial ecology as a resource management tool (Swetnam, 1999).

Background

In the southwestern United States, historical data gathered from both human databases (e.g. photos) and natural archives (e.g. tree rings) have aided in describing vegetation communities, identifying changes in species regimes, wildfire management, and distinguishing natural variation from anthropogenic impacts (Swetnam, 1999). These case studies have shown the usefulness of historical data by providing scientists and resource managers with a more comprehensive frame of reference, thus helping them better understand how and why current conditions came to be, and how those conditions are likely to change in the future. A better understanding of natural processes and relationships yielded more efficient and effective management of the landscape and natural resources. While these examples were focused on terrestrial resource management, the same principles and concepts have also been used in marine resource management.

In the context of marine resource management, historical ecological data have been used to support the shifting baselines hypotheses, and implicate overfishing as the root cause of numerous ecosystem collapses (Pauly, 1995; Jackson, 2001). Pauly (2005) underscored the importance of historical information when he coined the term "shifting baselines." Shifting baselines is the theory that humans have changed and influenced the natural environment over their lifetime, but the cumulative effects manifest themselves over much larger timescales. The result of a person's entire frame of reference being confined to a single lifetime is that those impacts are almost undetectable to the individual. Dr. Callum Roberts sums up shifting baselines and the importance of historical information in his book, *The Unnatural History of the Sea*:

> *"Early accounts of the abundance of fish and wildlife offer us a window to the past that helps reveal the magnitude of subsequent declines. They provide us with benchmarks against which we can compare the condition of today's seas. Such benchmarks are valuable in countering the phenomenon of shifting environmental baselines, whereby each generation comes to view the environment into which it was born as natural, or normal. Shifting environmental baselines cause a collective societal amnesia in which gradual deterioration of the environment and depletion of wildlife populations pass almost unnoticed. Our expectations diminish with time, and with them goes our will to do something about the losses. Seeing the world through the eyes of early travelers help us to better understand our own environment and gives us the impetus to find better ways to protect it."*

Shifting baselines can create problems for resource managers implementing management plans and scientists trying to make sense of dynamic marine ecosystems. Without a comprehensive and historically accurate frame of reference, setting benchmarks and monitoring may end up being skewed by shifting baselines. By stringing together observations of abundance or biodiversity over time, mangers and scientists alike can use applied historical ecology to help reduce the effects of shifting baselines in their goals and management decisions by using historical data to provide perspective.

Jackson et al. (2001) used paleological, archaeological, archival, and ecological records to investigate the underlying cause of various coastal ecosystem collapses, including the near extermination of the southern sea otter along the central coast region. Jackson's analysis of current data in a more historical context revealed a critical top-down effect of apex predators, which also happen to be species that are heavily exploited, on the entire ecosystem. In the case of the southern sea otter, kelp forest ecosystems in the northeastern Pacific began to decline following the rapid growth of the fur trade. With the sea otter nearly hunted to extinction by the mid-1800's, sea urchins, an important component of the sea otter's diet, increased dramatically, and a principal component of sea urchin diets are the holdfasts of kelp plants. In many deteriorating coastal ecosystems, historical over-harvest of any species can cause cascading effects up and down the food chain (Jackson et al. 2001). The deterioration of an ecosystem may be caused by a number of factors, anthropogenic or natural. However, the Jackson et al. (2001) analysis has shown that a deficiency of historical information can lead to misdiagnosis of an environmental problem, and in turn, possibly cause inappropriate or inadequate management actions.

Studies have also shown that even non-scientific information such as historical journal accounts can be useful in understanding natural history. Palomares et al. (2005) plotted historic trends of abundance of marine mammals, seabirds, sea turtles, fish and invertebrates in the Falkland Islands using only anecdotal information gathered from journal and log entries from early European expeditions. In other words, they translated qualitative judgments of abundance and biodiversity into quantitative data. The results indicated that the marine organisms most easily seen and most useful for human use accounted for the vast majority of the data. Furthermore, using present day information, they were able to show that the number of species historically classified as "abundant" have decreased, while the number of species classified as "rare" have increased (Palomares et al. 2005). While somewhat subjective, this analysis showed how even non-technical data can be used as corroborating evidence in identifying trends.

Significance

Despite the proven importance of historical information in resource management, historical records and documents are not always easily accessed, organized, or presented in a way that is useful to those who need it the most. The Monterey Bay National Marine Sanctuary History Project was initiated to rectify that problem. The Project consisted of two phases: an initial data mining and organizational stage to assess what kinds of material are available, and an analysis and product creation phase to provide examples of how a database of historical information can be utilized. Fortunately, the Sanctuary is rich in history.

The MBNMS is the largest National Marine Sanctuary in the contiguous United States and contains some of the most productive waters off the coast of California. A variety of marine habitats exist within the Sanctuary's boundaries, from intertidal sandy beaches, to subtidal kelp forests, to deepwater rocky reefs. In addition, some of North America's largest geologic features exist within the MBNMS, such as the Monterey Submarine Canyon, which compares in size with the Gran Canyon, and the Davidson Seamount, whose 7,480-foot peak lies 4,101 feet beneath the ocean's surface. These geologic features and habitats support a multitude of marine life including vast schools of microscopic planktonic organisms, the world's largest cetaceans, and every form of sea life imaginable in between (Monterey Bay National marine Sanctuary, 2011).

The highly productive marine ecosystems combined with the fertile lands of the central coast served as a home for many Native American tribes such as the Ohlone, and provided European explorers with places to settle. Monterey served as the first capital of California under Spanish rule, and was the major port of entry into California up until it became a state in 1848. The region's vast natural resources and extensive anthropogenic history make the Sanctuary an exceptional site for a study of applied historical ecology to help guide resource managers, scientists, and others interested in natural history (Library of Congress, 2011).

Methods

While applied historical ecology has proven its worth to resource managers and scientists, collecting and organizing all of the useful data can be a daunting task. Therefore, it makes sense to create a single database with a variety of information pertinent to an area of interest, such as the MBNMS. As such, the goals of the initial phase of the Project were threefold (Selbie, 2008):

1) To source historical material from which data regarding marine ecosystems and biological indicators of the MBNMS can be derived.
2) To digitize and store the data in a database where it is accessible.
3) To provide a system that is easily manipulated to serve as a resource for future historical analyses.

In order to compile what would become The Marine Historical Database, Selbie (2008) began by establishing a historical context, which would serve to hone in on specific spatial and temporal frames. The historical context for the Project was established by performing Internet searches using simple keywords, such as "Monterey," and "history." The next step was to create a list of search terms related to the historical context that would be used to mine a variety of online databases (Table 1). The initial bibliographic search returned over 6,000 records, about 350 of which contained ecological data pertaining to the Sanctuary. All the data were then organized into categories determined by McClenachan and Jackson (2007) (Table 2).

Table 1: Search engines and catalogues used by Selbie (2008) employed to gather historical documents relevant to the historical ecology of the MBNMS.

Search Catalogue	**Web Address**
Online Archive of California (OAC)	http://www.oac.cdlib.org
MELVYL (Catalogue of the University of California Libraries)	http://melvyl.cdlib.org
Google	http://www.google.com
Google Scholar	http://scholar.google.com
Google Books	http://books.google.com
SOCRATES (Catalogue of Stanford University)	http://jenson.stanford.edu
SIRIS (Catalogue of the Smithsonian Institution)	http://www.siris.si.edu
ARC (Catologue of the National Archives)	http://www.archives.gov/research/arc
JSTOR	http://www.jstor.org
Internet Archives	http://www.archive.org
New York Times Archives	http://www.nytimes.com/ref/membercenter/nytarc
NOAA Central Library	http://docs.lib.noaa.gov/rescue/Fish_Commision_Bulletin/data_rescue_fish_commision_bulletin.html
NOAA Satellite and Information Service	http://map.ngdc.noaa.gov/website/mgg/nos_hydro/viewer.htm
California Academy of Sciences Library	http://research.calacademy.org/research/library

Table 2: Results of the initial Internet search yielded approximately 350 records relevant to the historical ecology of the MBNMS.

Source	**Date Range**	**Number of Records**
Scientific Reports/Journal Articles	8500 b.p. - 2003	20
Maps and Charts	1786 - 1950	25
Early Exploration/Narrative Accounts	1602 - 1930	35
Newspapers	1850 - 1965	100
U.S. Fish Commission Publicatons	1870 - 1903	25
Fishery Bulletins/Statistical Records	1913 - 1965	50
Theses	1990	2
Photographs/Maps	1870 -1950	65

Sources from which pertinent biological or ecological data could be extracted (i.e. historical material from which biological indicators of the marine ecosystems of the MBNMS can be derived) were then digitized using scanners, cameras, and word processing programs into a FileMaker Pro database. Also housed in the database are the associated metadata, including author, year, title, and unique codes to facilitate database mining. In addition, cultural periods based on how marine resources were used and obtained were devised to further organize the data for future analysis (Lotze et al. 2006) (Table 3).

Table 3: Distinct cultural periods devised with guidance from Lotze et al. (2006) provided an additional means of organizing records. The descriptions characterize the time period in terms of how humans extracted and used natural resources in the MBNMS (Selbie, 2008).

Cultural Period (Lotze et al., 2006)	**Description (Selbie, 2008)**
Pre-European Native Americans (1500 - 1700)	Migratory peoples who are hunter and gatherer in nature, coastal resources use (in particular of the inter-tidal zone) occurred with limited offshore exploration. Trade routes
Early European Exploration (1700 - 1800)	Spread of western values, settlers establish missions outposts, opening of sea-lanes and commencement of trade.
The Beginning of Commercial Fisheries/Commercial Marine Resource Use (1800 - 1900)	People become cetralized into large, metropolitan cities. Catch moroe than needed for own consumption, develop
The Beginning of Industrial Fisheries (1900 - 1950)	Distance no object; consumer preference starts to drive product development.

By organizing the nearly 350 documents by cultural period, Selbie (2008) was able to use historical records to describe the MBNMS region in terms of use of natural resources by humans during each cultural period.

The purpose of the next phase of the Project was to further highlight the usefulness of historical records by providing an example of the type of analysis that can be conducted utilizing historical records. In addition, a timeline was created to display historical anecdotes and accounts regarding the MBNMS environment and resource use by humans (www.sanctuarysimon.org/timeline). As such, two goals were established for Phase 2 of the Project:

1) To search for specific references to abundance and biodiversity of select species found in the MBNMS to elucidate trends, providing better insight into how the past has affected the present, and how it may affect the future.
2) To show the progression of natural and anthropogenic change to the MBNMS region over time in a way that is interactive and easily understood.

In order to fulfill the first goal of Phase 2, previous applications of historical documents by resource mangers and scientists were reviewed to gain insight into how information from the Database could be analyzed. Selbie (2008) suggested an analyses similar to that of Palomares et al. (2005), which found that trends of abundance and biodiversity in the Falkland Islands could be drawn solely from anecdotal information recorded during European voyages (Palomares et al., 2005). Accordingly, for Phase 2 of the Project, the various documents in the Database were searched for accounts of perceived abundance of various species found within the MBNMS. As in Palomares et al. (2005), the anecdotes were compiled into functional groups in order to further organize the data (Table 4).

Table 4: Species were divided into four functional groups (similar to those in Palomares et al., 2005). "Species Noted" indicate those that were specifically identified in historical anecdotes.

Functional Group	Species Noted
Marine Mammals	Southern sea otter (*Enhydra lutris nereis*), California sea lion (*Zalophus californianus*), harbor seal (*Phoca vitulina*), humpback whale (*Megaptera navaeanglia*), gray whale (*Eschrichtius robustus*)
Fishes	Mackerel (*Scomber spp.*), smelt (*Osmeridae spp.*), flounder (Pleuronectiformes), shad (*Alosa spp.*), sardine (*Sardinops sagax*), sea bass (*Stereolepis gigas*), salmon (*Oncorhynchus spp.*), basking shark (*Cetorhinus maximus*)
Seabirds	Sea gulls (*Larus spp.*), pelicans (*Pelecanus occidentalis*), cormorants (*Phalacrocorax spp.*), fulmars (*Fulmarus spp.*)
Invertebrates	Mussels (*Mytilus californianus*), abalone (*Haliotis spp.*), crab (*Cancer spp.*), lobster (*Panulirus interruptus*)

A Monterey Bay example comes from the French explorer Jean-François de Galaup, comte de La Pérouse. One Journal entry dating back to 1786 during a voyage along the California coast read:

> *"It is impossible to describe either the number of whales with which we were surrounded, or their familiarity. They blowed every half minute within a half a pistol-shot from our frigates, and occasioned a most annoying stench. We were unacquainted with this property in the whale: but the inhabitants informed us, that the water thrown out by them is impregnated with this offensive smell, which is perceived to a considerable distance."*

Since the subject of the anecdote was cetaceans, it was put into the "Marine Mammal" functional group, along with data relating to the author, date, location, and source. Once the anecdotes were collected and organized in an Excel spreadsheet, the anecdotes were further categorized by assigning a ranking of perceived abundance. With guidance from the Palomares et al. (2005) study, and the help of a dictionary, rankings of perceived abundance were devised along with associated adjectives (Table 5).

Table 5: Adjectives and phrases commonly found within the documents indicating a level of perceived abundance were categorized based on dictionary definitions, examples from Palomares et al. (2005), and the judgment of the author. In order to reduce the subjectivity of this type of analysis, Palomares et al. (2005) recommends the process be repeated by others.

Perceived Abundance	Associated Adjectives and Phrases
Extremely Abundant	multitude, swarms, vast abundance, extremely abundant
Abundant	abounds with, riches, plentiful, stocked, extremely numerous, great numbers
Common	common, commonly, frequent, numerous, numbers
Rare	commercially extinct, entire lack, practically extinct, scarce
Extinct	extinct

For the example provided above, a perceived abundance ranking of "extremely abundant" was applied given the level of detail provided. In essence, largely qualitative judgments of abundance and biodiversity were turned into quantitative data points.

Approximately 200 documents of the original 350 entered into the Database were useful for this type of analysis. However, those pieces of information needed further refinement as many records concerned other regions of the eastern Pacific, from Alaska to Baja California. In order to further filter anecdotes that pertained only to the Sanctuary region, anecdotes attributed to areas outside the Sanctuary were not analyzed in this project. If the specific region could not be deciphered, the anecdote was only analyzed if the species being described is or was known to exist within the MBNMS. Lastly, redundant anecdotes were deleted. An anecdote was considered redundant if the same author repeated a level of perceived abundance for the same species or functional group in the same document. After this secondary screening was applied, only about 100 anecdotes were left to be analyzed.

Using this information, the data points were then graphed using a method similar to Pandolfi et al. (2003), whereby the ecological status (as opposed to perceived abundance) of functional groups were graphed additively over time. For example, Pandolfi et al. (2003) plotted the percentage of large predators that had an ecological status of "pristine," "abundant," "depleted," "rare," or "ecologically extinct" over time. A similar exercise was performed for Phase 2 of the Project, using anecdotal records to plot the percentage of observations for each functional group that was perceived to be "extremely abundant," "abundant," "common," "rare," or "extinct" through time.

The next step of Phase 2 was using the Marine Historical Database (Selbie, 2008) to create an interactive historical timeline of the Sanctuary. The timeline was populated with information from scientific reports, historical photographs, journals, theses, newspaper articles, and books. Users of the timeline are able to scroll along the timeline dating back to Pre-European North America up through the present. Small buttons and colored lines along the timeline indicate significant events or trends, and are marked with a short description. The button of line can be expanded with a mouse click to reveal more details about the event, such as the author of the work, its significance as it relates to other events and the natural history of the Sanctuary, and in most cases, a photo.

Results

An in-depth analysis of nearly 350 historical documents in the Marine Historical Database returned almost 200 anecdotes that were useful to an analysis similar to that of Palomares et al. (2005). These anecdotes were organized by cultural period and functional group (Table 6). The results show that marine mammals accounted for the majority of the anecdotes describing perceived abundance with 56 records, most of which were recorded between 1800 and 1900. Fishes accounted for the second highest number of anecdotes with 17, followed by invertebrates and seabirds with 15 and 11 anecdotes, respectively. When divided by cultural period, the period between 1800 and 1900 contained the most anecdotes with 48, followed by the periods between 1900-1950 with 30, 1700-1800 with 15, and 1500-1700 with 8.

Table 6: Results of a search for anecdotes pertaining to perceived abundance. Records are organized by Cultural Period and Functional Group. Functional Groups include marine mammals, fishes, seabirds, and invertebrates. Levels of perceived abundance include "extremely abundant," "abundant," "common," "rare," and "extinct." For example, 11 anecdotes were found in the Database indicating that marine mammal species were abundant during the Commercial Marine Resource use Cultural Period between 1800-1900. A total of 99 accounts of perceived abundance found in the Database were useful to this particular type of study pioneered by Palomares et al. (2005).

Cultural Period	Functional Group	Extremely Abundant	Abundant	Common	Rare	Extinct
Pre-European Native Americans 1500-1700	Marine Mammals	0	2	0	0	0
	Fishes	0	0	0	0	0
	Seabirds	3	0	0	0	0
	Marine Invertebrates	0	3	0	0	0
Early European Exploration 1700-1800	Marine Mammals	2	3	2	0	1
	Fishes	1	1	0	0	0
	Seabirds	1	1	0	0	0
	Marine Invertebrates	2	1	0	0	0
Commercial Marine Resource Use 1800-1900	Marine Mammals	2	11	5	11	0
	Fishes	3	4	0	0	0
	Seabirds	0	1	0	0	0
	Marine Invertebrates	4	3	0	2	0
Industrialized Fisheries 1900-1950	Marine Mammals	0	1	8	8	0
	Fishes	1	3	4	0	0
	Seabirds	0	3	2	0	0
	Marine Invertebrates	0	0	0	0	0

When perceived abundance was plotted against time, a variety of results were returned (Figures 1-4). For the marine mammal functional group, the initial results show a decline in the proportion of marine mammals considered to be "extremely abundant" to "abundant," and an increasing proportion of marine mammals considered to be "common" or "rare" (Figure 1). The perceived abundance of fishes shifted from "extremely abundant" to "abundant" and "common" (Figure 2). The invertebrate functional group exhibited upward trend followed by a downward trend with perceived abundance changing from "abundant" to "extremely abundant," and then to "abundant" and "rare" (Figure 3). Finally, an analysis of anecdotes pertaining to seabirds also exhibited a downward trend (Figure 4).

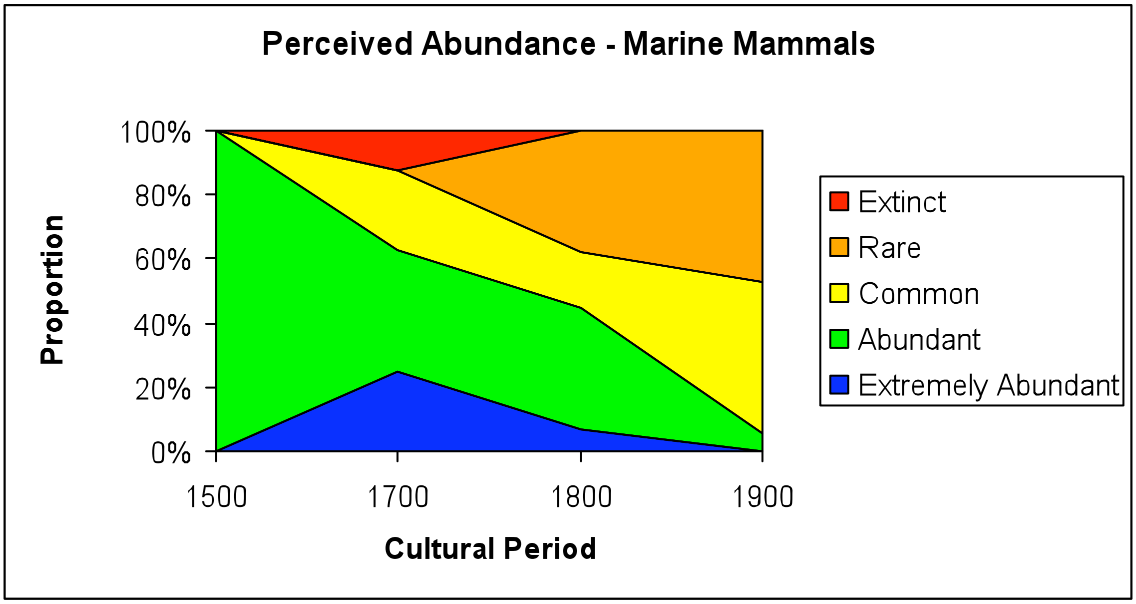

Figure 1: Graph depicting change in perceived abundance of marine mammals over time. For example, at the beginning of 1800, records collected from the Monterey Bay National Marine Sanctuary Marine Historical Database suggest that about 2 out of 29, or 7%, of anecdotes concerning marine mammal species implied that marine mammals were “extremely abundant,” 11 out of 29 (38%) “abundant,” 5 out of 29 (17%) “common,” another 38% “rare,” and 0% extinct. In other words, the results of this analysis show that marine mammals species characterized as being “extremely abundant” have fallen, while marine mammal species characterized as being “common” and “rare” have increased. For the marine mammal functional group, n = 56 records.

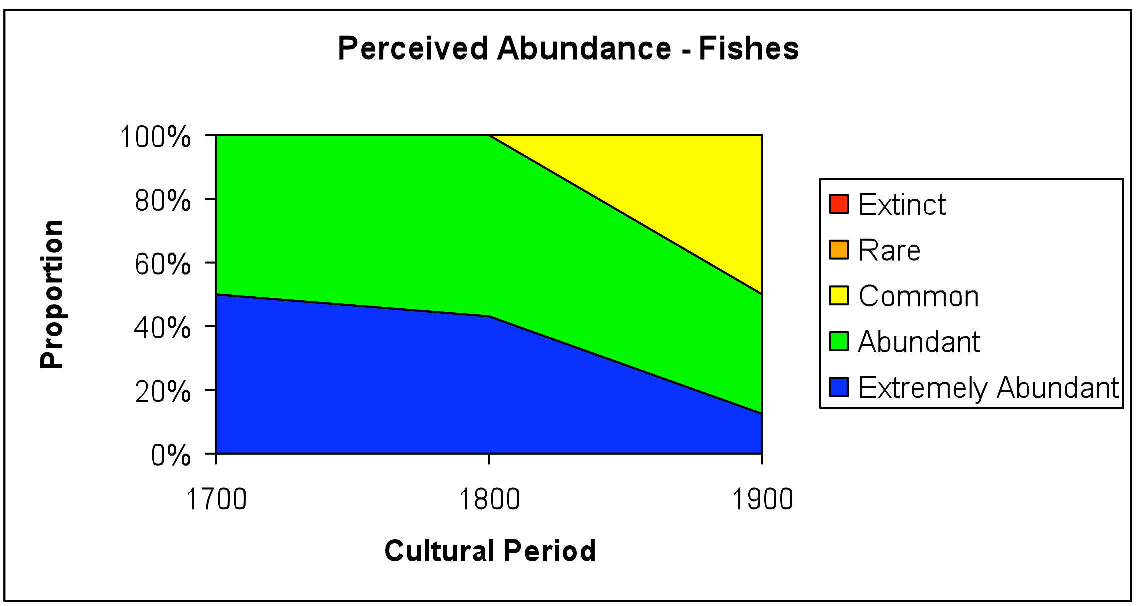

Figure 2: Trends from the data also suggest that the perceived abundance of fish species have gravitated from “extremely abundant” to “abundant” and common” over time. For the fishes functional group, n = 17 records.

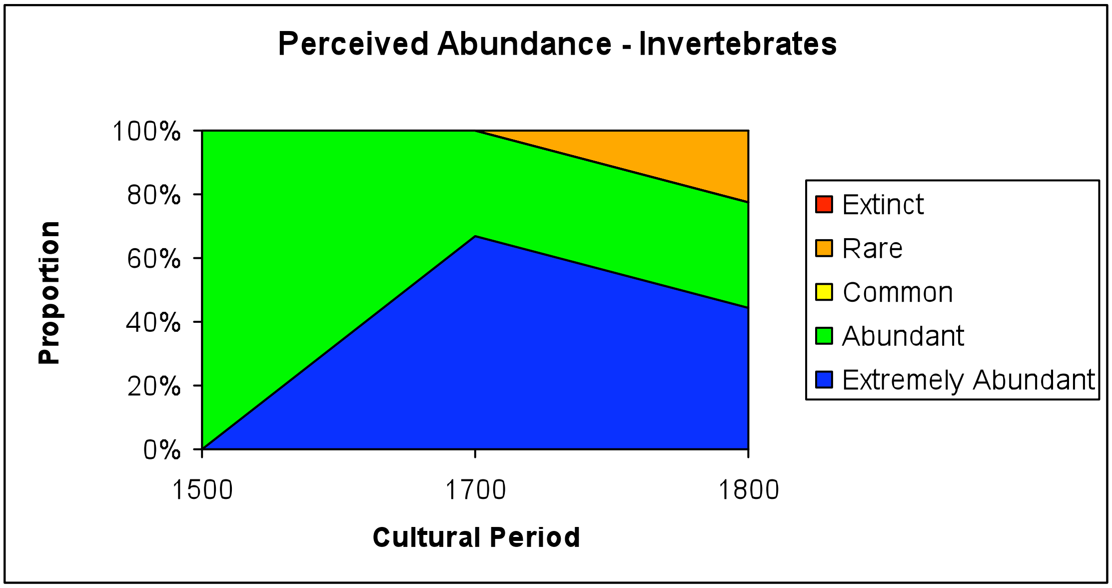

Figure 3: At first, and upward trend in perceived abundance was noted amongst marine invertebrate species between 1500 and 1700, which was followed by a decline immediately after. For the marine invertebrate functional group, n = 15 records.

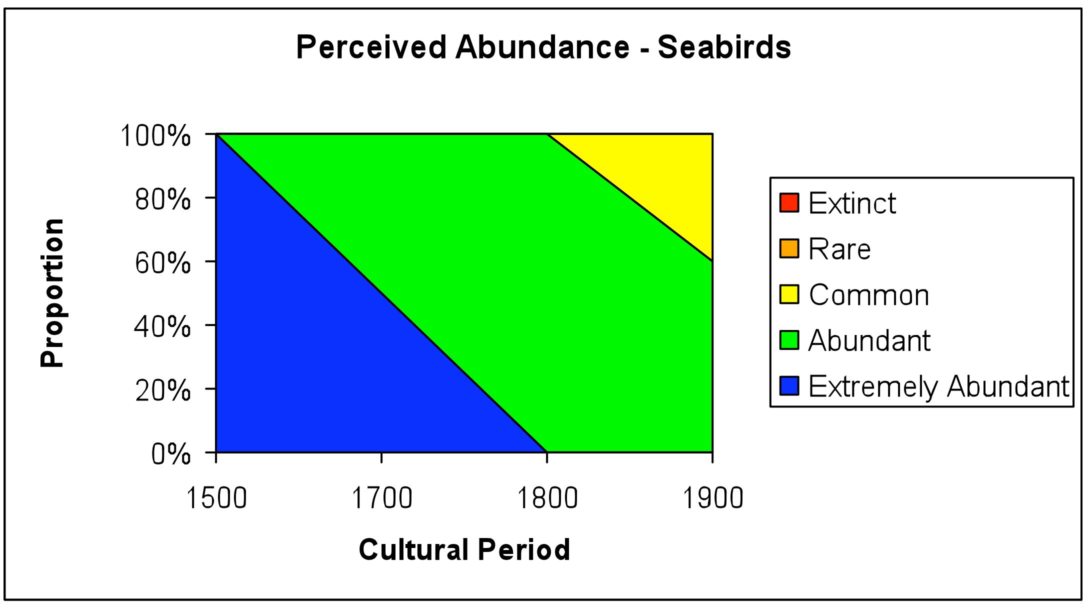

Figure 4: The seabird functional group exhibited a similar trend to that of the fishes functional group, showing a change from "extremely abundant," to mostly "abundant" and "common" by 1900. For the seabird functional group, n = 11 records.

The anecdotes were able to provide about two thirds of the 138 data points entered into the timeline. The rest of the data points consist of scientific records from State Fish Bulletins and historical facts provided by government, museum, and university websites. Each piece of data, when applicable, carries with it background information that further relates it to the ecological and anthropogenic history of the Sanctuary, and when available, has a picture associated with it (Figure 5). Users of the website are able to see records that date back to the 1500's and go up to the present. In addition, a filter tool has been added to allow the viewer to isolate anecdotes of specific topics on the timeline, such as functional groups, water quality, the Elkhorn Slough, etc. The timeline may be found online at: www.sanctuarysimon.org/timeline.

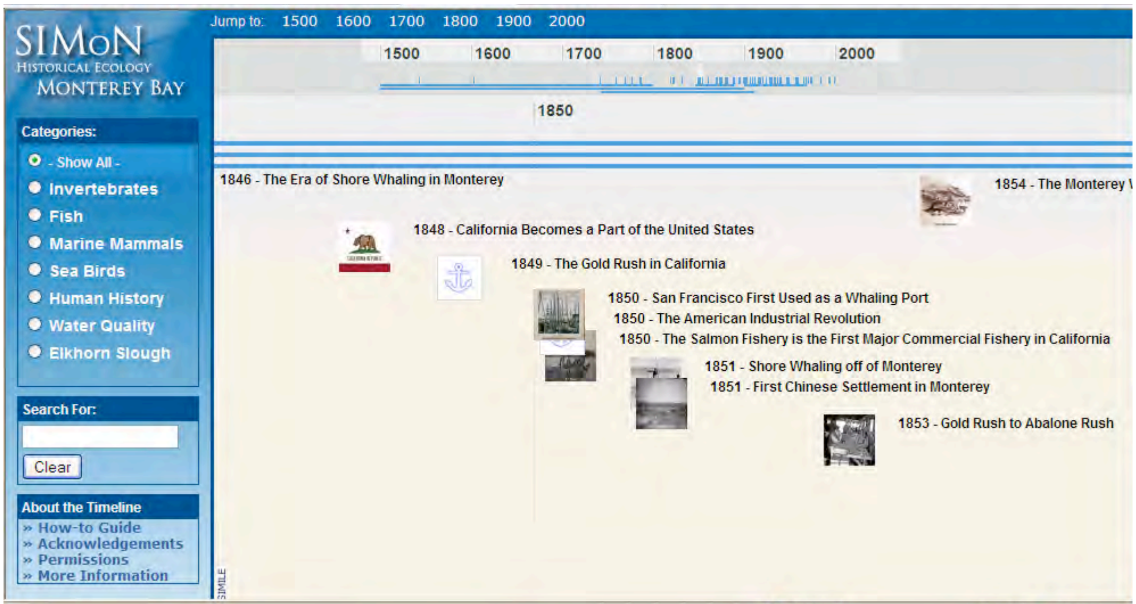

Figure 5: The interface of the Monterey Bay Marine Sanctuary Historical Ecology Timeline as seen on the Sanctuary Integrated Monitoring Network website (www.sanctuarysimon.org/timeline). The Timeline features over 100 photographs, anecdotes, quotes, and background information linking the anthropogenic and natural histories that have influenced and shaped the Monterey Bay National Marine Sanctuary's environment over time.

Discussion

At project inception, a historical analysis similar to that of Palomares et al. (2005) and Pandolfi et al. (2003) was to be conducted, whereby anecdotes indicating relative abundance and biodiversity are used to plot abundances or ecological statuses of functional groups over time. Of the 350 historical documents housed in the Marine Historical Database, about 200 records were useful for this type of analysis, and of those, only half could be attributed to the region that would become the Sanctuary or to species that could be found in the Sanctuary. The data, therefore, does not mean much by itself. However, when paired with existing information, notably the characterization of each cultural period completed by Selbie (2008), the trends and data that could be analyzed produced some interesting results.

Not surprisingly, accounts of marine mammal abundance dominated the historical anecdotes collected, much like Palomares et al. (2005) observed. This is most likely due to the fact that marine mammals are highly visible and were targeted for their oil, pelts, and meat (Palomares et al. 2005). Initial results indicate that perceived abundance of marine mammals (which included cetaceans, pinnipeds, and fissipeds in this analysis) has decreased over time. While these data support information that is already well known, it shows the usefulness of even non-scientific information in identifying trends.

Another notable result was the increase in the number of species identified in observations. For example, the earliest anecdotes mention that whales in general were "abundant." However, the data show that as time progressed, those recording their anecdotes began to differentiate between whale species. This may reflect the fact that as the whaling industry grew beginning in the early 1800's whalers began to make distinctions between whale species, noting that some had superior blubber to others, or some were easier caught than others. They also recognized that some species were rarer or more abundant than others. This led to specialized hunting techniques and seasons for different whales, and perhaps more importantly, paved the way for consumer demand to drive the market and opened the door for industrialized fisheries (Selbie, 2008). Whaling Captain Charles Melville Scammon wrote an entire book detailing the seasons and methods used to hunt marine mammals on the west coast of North America entitled, *The Marine Mammals of the Northwestern Coast of North America: Together With an Account of the American Whale-Fishery*. The major difference between the era of commercial fisheries and the era of industrialized fisheries was a general use and extraction of marine resources in the commercial period, as opposed to a more consumer dependent and specific use and extraction of marine resource use in the industrial period. This shift is reflected in the data and results.

The data for the other functional groups was not as robust as the data for marine mammals. One explanation for this lack of data is that the amount of historical information that exists regarding a particular functional group is correlated with how useful they were to humans (Palomares et al. 2005). As stated before, marine mammals dominated historical anecdotes in this analysis. Mass harvest and exploitation of cetaceans, pinnipeds, and fissipeds predated mass human extraction of invertebrates and fishes on the west coast by decades (Selbie, 2008). Another factor possibly affecting the disproportionate amount of marine mammal anecdotes compared to other functional groups is visibility. Explorers on the land and sea could easily spot marine mammals. Invertebrates and fishes, however, are more difficult to see and quantify. This observation may account for the initial upward trend in the perceived abundance of invertebrates. Before the near collapse of the southern sea otter population in the mid 1800's, they exerted a strong top-down control over abalone, one of their main food sources. With no sea otters to consume them, the abalone population exploded and the commercial abalone fishery rapidly grew by the end of the 19th century. The shift in perceived abundance of invertebrates from "abundant" to "extremely abundant" may be explained by the fact that abalone became more valuable, or simple because there were more of them. What few anecdotes do exist regarding invertebrates such as abalone seem to fit historic and scientific data and trends.

Fishes accounted for the third highest number of anecdotes at 17. The trend shows a shift from "extremely abundant" and "abundant" in the 1700's, to "abundant" and "common" through 1900. This change in perceived abundance could be due to the fact that mass harvest of fishes did not begin until the mid 1800's with the salmon fishery. In addition, most of the anecdotes pertaining to fishes were recorded in the cultural period between 1900 and 1950. This could also reflect that the commercial fishing industry did not dominate the west coast fisheries until after the whale and abalone fishery fell out of favor by the latter half of the 19th century.

Seabirds, despite being arguably more ubiquitous on land and visible than any of the other functional groups, accounted for only 11 anecdotes. This is probably due to the fact that seabirds have never been a major target of human consumption. As a result, seabirds, having never been a focus of mass harvest efforts, were largely ignored by those taking stock of the Sanctuary's wealth of natural resources.

The timeline provides a linear and interactive tool that illustrates the historical ecology of the MBNMS using historical anecdotes to describe marine biodiversity and abundance, as well as historical data to provide background and context for those anecdotes. Together with the analysis, they provide a stronger link between human and natural history. For example, the anecdotes and historical records revealed an interesting link between human attitudes and perceptions and the decline in many whale species following decades of unrelenting whaling operations at the close of the 19th century. The data reveal that as whaling ceased due to the scarcity of whales, residents on the coast began to lament the loss, as whales were a major source of revenue for the community. As a result of there being fewer whales and better technology (thanks to the industrial revolution), the sardine fishery grew to become the largest fishing industry in California by the first decades of the 20th century. The whales began to return to the coast and began to compete with fishermen for sardine. As a result, coastal Californians began to advocate the culling of the very whales they depended upon years earlier. The string of anecdotes and data points displayed by the timeline shows that how humans see and treat the environment is based largely on how they use it.

Conclusion

When information useful for analyses such as Palomares et al. (2005) was gathered, it did not add up too much – roughly 200 data points. When those documents were further refined to reflect only what has occurred within the boundaries of the Sanctuary, the result was only 99 anecdotes. Despite having relatively few data points that were based largely on qualitative information, when paired with other scientifically based trends and knowledge, this Project showed the value of historical documents (technical or otherwise). The data and trends appear to match well established trends in the Sanctuary, namely the decrease in marine mammal populations throughout the late 1800's and into the 20th century, and the explosion of the abalone population following the collapse of southern sea otter populations. In addition, the increase in the number and variety of anecdotes and species seems to coincide with the shift from general marine resource use in the commercial fishing period to the more consumer driven, specific marine resource use that characterizes the industrial fishery period. Moreover, this analysis provides valuable insight into how human history and people's attitudes and perceptions regarding marine resources have changed over time, and affected the status of our resources today. Consequently, resource managers and scientists attempting to better manage marine ecosystems can identify ways to change the way we extract and perceive marine resources.

Similarly, the timeline was able to more clearly link people and their environment through space and time by combining anecdotal accounts of coastal environments with historical data in a way that is visible and interactive. By combining the useful historical ecological data pertaining to the MBNMS region into one database that is accessible to anyone, the timeline serves as a tool for outreach and education, and a tool for identifying the major and underlying ecological trends in the Sanctuary and distinguishing natural variation from human impact. Additionally, the timeline and associated data could aid in resource management by providing a more historical context when setting goals and creating management plans. By housing useful historic information relating to a variety of interrelated topics in one place that provides users with a temporal frame of reference, the timeline can help us better understand the complex relationships between humans and their actions, the land, and the sea.

Despite the subjectivity of historical accounts, the importance and applicability of historical data should not be overlooked. Study after study indicate that both the lack of understanding of the history of an ecosystem and the omitting of historical information has led to the mismanagement of fisheries and the implication of erroneous causes of ecosystem collapses in the marine ecosystems (Pauly, 1995 and Jackson et al. 2001). This project has shown the relevance of historical data to the Monterey Bay Sanctuary Region.

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